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April 30, 2014

Mr. Steven Way
On-Scene Coordinator
Emergency Response Program (8EPR-SA)
US EPA Region 8
1595 Wynkoop Street
Denver, CO 80202-1129

Subject: Final Design Report, St. Louis Tunnel Hydraulic Control Measures Rico Argentine Mine Site – Rico Tunnels Operable Unit OU01 Rico, Colorado

Dear Mr. Way,

An electronic file in PDF format of the *Final Design Report, St. Louis Tunnel Hydraulic Control Measures, Rico Argentine Mine Site – Rico Tunnels Operable Unit OU01 Rico, Colorado*, dated April 30, 2014, is being submitted to you today via email. Three hard copies of the report will also be delivered to your office via FedEx no later than close of business May 1.

Atlantic Richfield Company is submitting this report in response to requirements in Task D of the *Removal Action Work Plan* accompanying the Unilateral Administrative Order for Removal Action, Rico-Argentine Site, Dolores County, Colorado, U.S. EPA Region 8, Docket No. CERCLA-08-2011-0005.

If you have any questions, please feel free to contact me at (951) 265-4277.

Sincerely,

Anthony R. Brown

Anthony R. Brown
Project Manager
Atlantic Richfield Company

c: Ronald Halsey, Atlantic Richfield Company (via e-mail)
Terry Moore, Atlantic Richfield Company (via e-mail)
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Submitted to:
US EPA Region 8
Denver, CO

Submitted by:
AECOM
Denver, CO
60314368
April 30, 2014

Final Design Report
St. Louis Tunnel Hydraulic Control Measures

Rico-Argentine Mine Site – Rico Tunnels
Operable Unit OU01
Rico, Colorado

AECOM

Submitted to:
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Final Design Report
St. Louis Tunnel Hydraulic Control Measures

Rico-Argentine Mine Site – Rico Tunnels
Operable Unit OU01
Rico, Colorado

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List of Acronyms

ac-ft	acre feet
amsl	above mean sea level
cf	cubic feet
cf/s	cubic feet per second
cm/s	centimeters per second
ft	feet
ft^2	square feet
ft/s	feet per second
gpm	gallons per minute
HDPE	High density polyethylene
NW	northwest
PDR	Preliminary Design Report
SE	southeast
SLT	St. Louis Tunnel
UAO	Unilateral Administrative Order
USEPA	U.S. Environmental Protection Agency
VFD	variable frequency drive

1.0 Introduction

The St. Louis Tunnel (SLT) Adit Hydraulic Control Measures Project addresses specific requirements of the U.S. Environmental Protection Agency (USEPA) Unilateral Administration Order (UAO) (USEPA, 2011a) and Remedial Action Work Plan (USEPA, 2011b), specifically Subtask D2 of Task D, "Final Design of Adit Hydraulic Controls." The location of the adit hydraulic control measures project is shown on Figure 1.

The objectives of the SLT Adit Hydraulic Control Measures Project are to: 1) gather and convey essentially all of the tunnel discharge (to the extent practicable) to the selected water treatment system in a controlled manner; and 2) mitigate the release of settled solids and debris that may have accumulated in the SLT behind the blockage in the collapsed adit area.

1.1 Summary of Preliminary Design Report

A Preliminary Design Report (PDR) was prepared and submitted to the USEPA on October 30, 2013 (AECOM, 2013). The PDR summarized a final set of alternatives to achieve the objectives indicated above, which were adopted following consideration and preliminary evaluation of a wide array of potential concepts. The PDR presented: 1) the technical characterization and hydraulic and geotechnical considerations of six short-listed alternatives; 2) a comparative evaluation among the alternatives resulting in a recommended alternative and back-up alternative to carry forward; and 3) preliminary (i.e., 30-percent) design of the recommended and back-up alternatives.

The alternative recommended by the PDR was to leave the existing debris plug in place and improve the collection and conveyance of water leaving the debris plug. The open, collapsed portion of the tunnel at the west end of the excavation into the face of CHC hill would be reconstructed to remove colluvial debris and timber supports from the end of the tunnel, allow accurate measurement of mine water discharge, and facilitate conveyance of that mine water to the final treatment system. The existing debris plug inferred present in the colluvial portion of the SLT would continue to convey tunnel discharges from the underground to the surface.

The PDR also recommended that the existing AT-2 casing continue to function as a tunnel water level monitoring and water quality sampling point. It would also serve as a "relief well" to discharge tunnel flows if the permeability of the debris plug decreases either suddenly or gradually over time by internal collapse or clogging, and during times of sufficiently high flow from the mine workings, resulting in further back-up of water in the SLT and interconnected underground workings. Grading would be improved so that water discharged through AT-2 would flow toward newly constructed wingwalls and be directed to discharge into the improved channel below the debris plug. In addition, the PDR recommended that one or more additional relief wells of appropriate capacity be installed in the vicinity of AT-2 if plugging and resultant increased back-up of head above the debris plug occurs and is not adequately mitigated by drainage through AT-2.

Finally, the PDR recommended that concrete wingwalls be constructed at the downgradient end of the debris plug and extend laterally to the toes of the slopes in the lower reach of the terrain trap. The wingwalls would intercept water that either currently is, or in the future may, leak laterally into more pervious zones of colluvium from the debris plug or the upgradient remaining colluvial reach of the SLT.

1.2 Final Design Revisions

Following submittal of the PDR, detailed constructability and hazard reviews for the recommended alternative were performed as part of the final design process. During these reviews, significant safety risks were identified to implement this alternative. Drilling additional relief well(s) near AT-2 posed hazards for crews working for an extended period of time in a confined area within the terrain trap with steep surrounding slopes and limited egress from the area. Grading to improve the channel below the debris plug and installation of wingwalls would require excavation along the steep side slopes in the terrain trap which could de-stabilize the slopes, putting the workers at risk from a slope failure or rock fall. In addition, during the constructability review it was determined that a relatively high cost to implement the recommended alternative still relied upon the long-term adequacy of the debris plug. As indicated in the PDR, it was proposed to retain Alternative 5 (Tunneling) as a potential future replacement for the recommended alternative in the event that a condition or issue arises during operation and monitoring that brings into question the long-term adequacy of the recommended alternative. If at some point it is determined that the recommended alternative is not functioning adequately, the relatively high cost to implement the recommended alternative would be lost by implementing the Tunneling alternative. For these reasons, some revisions were made to the recommended alternative to improve safety for workers implementing the work and potentially reduce initial costs.

An alternative involving pumping of SLT mine drainage from AT-2 was evaluated for periods of peak flows or in the event of increased hydraulic head in the tunnel due to plugging of the debris plug. The evaluation of pumping alternatives was made to assess the most feasible means of controlling water levels within the SLT through the existing AT-2 as an alternative to drilling additional relief wells. The purpose of the pump is to control the water build-up behind the existing debris plug in the colluvial reach of the inferred intact tunnel. This would be accomplished by pumping water from the SLT to a point beyond the collapsed area of the SLT.

Alternative Description

The final revised alternative includes leaving the existing debris plug in place and installing a pumping system to manage tunnel water during peak discharge periods, or sudden or gradual blockage of the debris plug. In order to meet the objective of gathering, to the extent practicable, and conveying to treatment essentially all of the tunnel discharge, this alternative relies on the interpretation of available data from recent investigations that losses of tunnel discharge flows to the colluvium out-by the rock portion of the SLT (including from the debris plug and the open, collapsed reach of the tunnel) are minor and acceptable. These losses are estimated as on the order of 60 gallons per minute (gpm) (which is approximately 9 percent of the average discharge at DR-3 from May 2011 through January 2014) in the colluvial reach of the tunnel from the original portal structure to the contact with Hermosa formation bedrock.

<u>Components and function</u>

The major components of this alternative are illustrated on Figure 2 and described (in terms of both form and function) as follows:

Existing debris plug. The existing debris plug inferred present in the colluvial portion of the SLT will continue to convey tunnel discharges from the underground to the surface. The debris plug is assumed to be approximately 70 feet (ft) long, comprised of a heterogeneous mixture of broken and displaced timber supports (posts, beams and lagging) and colluvium. Based on hydraulic modeling, the bulk hydraulic conductivity of the debris plug is estimated as on the order of 3.9 centimeters per second (cm/s) (equivalent to clean, open work gravel).

AT-2 casing. The existing steel casing installed in boring AT-2 is approximately 22 ft long and extends from about 2.3 ft above the existing ground surface to what is inferred as an intersection with the north wall of an apparently open reach of the SLT. The internal diameter of the casing is 4-inches. The AT-2 casing will be used to convey water from the SLT to a self-priming centrifugal pumping system which will discharge tunnel flows if the permeability of the debris plug decreases. This decrease in permeability may occur either suddenly or gradually over time by internal collapse or clogging, and during times of sufficiently high flow from the mine workings, resulting in further back-up of water in the SLT and interconnected underground workings.

Pumping system. As discussed above, the pumping system would consist of a self-priming centrifugal pump with an electric motor that would be positioned at the AT-2 well head. Water would be drawn from the adit via the 4-inch diameter AT-2 casing. The pump is connected to the 4-inch intake line and a 6-inch discharge line to decrease potential flow restrictions. The pumping system would require a permanent electric supply and a control system consisting of a pressure transducer installed in monitoring well BAH-01 that would start and stop the pump when the hydraulic head exceeds a set point of elevation 8,865 ft. The pumping system would be housed in a small enclosure to protect it from environmental conditions.

Discharge piping. The discharge piping would consist of a 6-inch diameter pipe run at the surface from the AT-2 casing to a point near the end of the terrain trap where it will combine with flow from drainage through the debris plug. The pipe would be sloped to drain by gravity when the pump stops to eliminate the potential for freezing of the line.

1.3 Report Organization

Section 1.0 presents the rationale, objectives, and scope and organization of this *draft Final Design Report*, and provides a brief summary of the alternative proposed in the PDR and the revised final alternative proposed herein. Section 2.0 briefly characterizes the site setting and presents key background information regarding site conditions that together are the basis for preparing a design for the recommended alternative. Section 3.0 lists key design criteria to be met by the alternative. Section 4.0 presents the hydraulic conditions, opportunities and constraints applicable to the design, and construction and operation of the alternative. Section 5.0 describes the operation and maintenance of the proposed system.

2.0 Setting/Background

The *Adit and Portal Investigation Report – 2013 Update* (Atlantic Richfield, 2013) documents extensive geologic, geotechnical, and geophysical field exploration and geotechnical laboratory testing performed at the collapsed adit area of the SLT over the past three years. Section 5.0 of that report also presents a detailed characterization of the site, based on the field and laboratory investigations. A brief summary of the history of the SLT in this area and of the most relevant geologic/geotechnical conditions present follow.

This proposed alternative and design for this part of the overall remedy is focused on the portion of the SLT that was originally driven through approximately 330 ft of colluvium at the base of CHC Hill, then into bedrock of the Hermosa Formation to just beyond the reach that was reportedly lagged (i.e., approximately 35 ft into the rock from the contact with colluvium). Based on archival tunnel geologic mapping and historic photographs, it is inferred that the tunnel is nominally 7 ft high and 9 ft wide.

Available aerial photographs show that a major excavation was made over the downgradient reach of the SLT sometime between August 1950 and October 1952. The resultant steeply sloping U-shaped excavation is now referred to as the "terrain trap." The slopes in this area are excessively steep and judged at best metastable to unstable at their angle of repose. Cobble- and boulder-size rocks roll and tumble down these slopes, especially following rainfall and snowmelt events. Finer (sand and gravel fraction) colluvium also continues to be transported down slope by gravity, accumulating at the toes of the slopes.

Review of subsequent aerial photography is interpreted to show that the remaining ground over this reach of the tunnel remained relatively undisturbed until at least August 1989, except that raveling of the slopes removed the benches visible shortly after the initial excavation. Sometime later, inferred by review of available aerial photography as being before September 1998, it appears that someone borrowed the remaining colluvial cover over the first approximately 250 ft of the tunnel in-by the original portal location. In this reach, the back (i.e., the roof) of the tunnel is now mostly gone and the tunnel is partially filled with damaged and displaced timber supports and what is assumed to be displaced colluvium ranging from silty sand to cobbles and boulders. The upper end of the now "collapsed, open" portion of the tunnel is blocked by a boulder at least 7 ft in visible dimension and water currently begins emerging at the surface at this point. It is inferred that the next approximately 70 ft of the tunnel upgradient in the colluvial section is at least partially plugged with displaced colluvium and broken timber supports. This reach is referred to as the "debris plug." Recent geophysical profiling suggests that at least some of the remaining approximately 60 ft of the tunnel in the colluvial reach to the contact with Hermosa Formation bedrock remains open.

The key topographic and subsurface conditions described above are illustrated on Figure 2. The geologic conditions are best illustrated on Figures 5.1 and 5.2 in the *Adit and Portal Investigation Report – 2013 Update* (Atlantic Richfield, 2013).

3.0 Design Criteria

Key design criteria include, but are not necessarily limited to:

- Accommodate peak flows to the extent possible up to the maximum discharge of 5.2 cubic feet per second (cf/s) (2,300 gpm), based on historic data and 60 years of simulated flows at DR-3 from the Rico Site Underground Workings Hydraulic Model.
- Where pipe is necessary to convey SLT discharge flows, design piping to resist scaling and eventual clogging, and provide appropriate redundancy of piping conveyance where necessary.
- Provide access to discharge line piping for jetting and/or pigging equipment to control scaling; well piping to be pulled for cleaning scale if/as needed.
- Minimize seepage losses from constructed conveyances (piping or open channels).
- Design life for all components is nominally 50 years.
- Provide for monitoring of water head in the SLT, surface water flow, depth to groundwater, and surface and groundwater quality as appropriate to this alternative.
- Accommodate increasing hydraulic head if encountered over project life to provide for adequate flows by future designed additions or changes to the system if/as needed.

4.0 SLT Hydraulic Control System Design

The following discussion summarizes the methodology used to simulate hydraulic conditions to support the design of the revised alternative presented in Section 1.2. The pre-debris plug condition is also modeled to provide context and perspective.

4.1 Underground Hydraulics

The SLT acts as a drain for groundwater at and in the vicinity of the Rico-Argentine Mine Site. The network of interconnected underground workings in Telescope Mountain (and its lower slopes, known as CHC Hill) and Dolores Mountain drain to the St. Louis (or 500) level and discharge from the SLT to the St. Louis Ponds System. Flow is measured at DR-3, downstream of the existing debris plug, and collapsed, open lower section of the SLT, as described in Section 2.0. Flow measurements at this location have occurred intermittently since the late 1970s and represent a small, incomplete dataset. Inflow values are critical to evaluation of the hydraulic conditions within the SLT and the overlying colluvium out-by the rock portion of the tunnel under different design alternatives.

To supplement the DR-3 dataset, a preliminary hydraulic model (Rico Site Underground Workings Hydraulic Model) was utilized to estimate daily flows at DR-3. The model is driven by precipitation and snowmelt, and was calibrated using DR-3 flow measurements and Dolores River flow measurements. The model uses a water balance approach based on total available water, surface runoff, mine water runoff, and water lost due to physical processes (e.g., evapotranspiration). The predicted flows from this model are the best available data with which to analyze the hydraulics associated with different flow conditions at the tunnel debris plug.

Figure 3 shows the predicted daily flows at DR-3 between 1951 and 2011. These daily inflow data were assumed to be representative of flows inside the SLT (i.e., negligible losses to colluvium are assumed, as discussed in Section 7.3 of the PDR [AECOM, 2013]) and were used as the inflow input to the flow routing model discussed next. The apparent truncation of modeled flows at approximately 5 cf/s is the result of the physical limitations inherent in the model (and in the field) of the degree of infiltration and soil/fault/fracture "abstraction" storage of snowmelt and rainfall that can ultimately report to DR-3. In other words, there is a physical limit to the amount of precipitation (snowmelt or rainfall) that can enter the underground workings regardless of the amount of the amount of precipitation that occurs. The excess flows that would otherwise report to DR-3 runoff to the stream systems instead, and show up as higher stream flows. Note that the stream flows are not limited in the same way as the mine workings inflows so that years with sufficiently high precipitation (beyond the capacity of the mine workings to absorb) can and do show stream flow peaks that appear clipped in the mine workings model outflow.

4.2 Flow Routing

A spreadsheet model was developed to route flow from the SLT (upstream of the debris plug) through different outlet conditions and to predict accumulation of mine water and the associated increase in head within the underground workings, using the storage-indication level pool routing method. This method uses the stage-storage relationship and stage-discharge relationship to route flow. A stage-storage curve was developed for the 500 level from the tunnel portal through the SLT and the southeast (SE) and northwest (NW) cross-cuts using known elevations and assumed tunnel dimensions of 7 ft in height by 9 ft in width. A total of 46 ft of head is available within the modeled portion of the 500 level, which is equivalent to approximately 600,000 cubic ft (cf) or 13.8 acre ft (ac-ft) of storage (Figure 4). Head loss within the tunnel was assumed to be negligible.

4.2.1 Rating curves

Discharge rating curves were developed for the different outlet conditions. The methods used to develop these relationships are described below:

Debris Plug

The stage-discharge relationship for the current condition debris plug flow was estimated using Darcy's Equation:

$$Q = K\frac{\Delta H}{\Delta L}A$$

Where: Q = discharge (cf/s)

K = hydraulic conductivity (feet per second [ft/s])

ΔH = Change in height across debris plug (ft)

ΔL = Length of debris plug (ft)

A = Cross sectional area of debris plug (square feet [ft^2])

Hydraulic conductivity for the debris plug was back calculated using known water levels in AT-2 and known flow rates at DR-3. This calculation was performed for three manual water level measurements taken in March, April, and June of 2013 at AT-2, and yielded an average value of 0.13 ft/s (3.9 cm/s).

Relief Well

A stage-discharge curve was developed for the relief well by solving the energy equation and the Hazen-Williams equation simultaneously. The conservation of energy was solved for discharge as:

$$Q = A\sqrt{(H_1 - H_2 - H_L - H_{ml}) * 2g}$$

Where: Q = discharge (cf/s)

A = flow area inside pipe (ft^2)

H_1 = upstream head, measured from tunnel invert (ft)

H_2 = distance to discharge point or top of casing, measured from tunnel invert (ft)

H_L = head loss (ft)

H_{ml} = minor head losses (ft)

G = gravity (ft/s^2)

The Hazen-Williams equation was used to calculate head loss as a function of discharge:

$$H_L = \left[\frac{\frac{Q}{A}}{1.318 * C * \left(\frac{d}{4}\right)^{0.63}}\right]^{1.85} * L$$

Where: HL = head loss (ft)

Q = discharge (cf/s)

A = flow area inside pipe (ft^2)

C = roughness coefficient, 100 for steel

d = pipe diameter (ft)

L = pipe length (ft)

Table 1 shows the design parameters used for each of the alternatives.

4.2.2 Results

All head values are measured from the invert of the tunnel at the upgradient end of the inferred existing debris plug, with maximum heads and average heads quantified using the full 60-year period of record of simulated flows. Post 1999 maximum heads were quantified using analysis results from the time period when the current debris plug is inferred to have existed. The maximum head prior to the installation of AT-2, with the only discharge occurring through the debris plug, was 44 ft (Table 2). This represents the worst case condition modeled by allowing head to build up as high as necessary in the SLT and SE/NW cross-cuts. The post-1999 maximum head value of 41 ft represents the estimated worst case condition that the current debris plug has been exposed to. The maximum head under current conditions, where water discharges through the debris plug and AT-2 is utilized as a relief well when heads increase to its discharge invert, was 29 ft. The maximum head under the proposed system, where water discharges through the debris plug and AT-2 is utilized for a pumping system when heads increase to its discharge invert, was 25 ft.

4.2.3 Pumping System

For the purpose of installing a pumping system into the SLT, access will be through an existing 4-inch diameter steel casing (AT-2) daylighting at ground surface approximately 14 vertical ft above the tunnel floor. The casing for AT-2 was installed from the ground surface to the tunnel at an angle of approximately 32 degrees and a total original length of 21 ft (approximately 2 ft at the 32 degree angle were above ground). The head loss characteristics include the approximately 2 ft of elevation head plus line losses from a 21-foot borehole casing and 100-foot above ground conveyance pipeline. The total dynamic head varies based on each pump evaluated due to the various pumping rates and discharge pipe sizes.

A flow evaluation was performed to determine the design pumping rate to maintain a controlled water elevation in the tunnel. A self-priming centrifugal pump system was selected as the only type that could achieve the highest pumping rates to be effective for this application. The pump evaluated consists of a self-priming centrifugal pump with an electric motor that would be positioned at the AT-2 well head. Water would be drawn from the adit via the 4-inch diameter casing and discharged through a 6-inch discharge line.

The optimum pumping system could produce a maximum flow of approximately 1,000 gpm. The pump has a maximum suction lift of 25 ft which exceeds the required 14 ft (maximum drawdown in the AT-2 casing).

After determining the maximum flow that could be removed from the SLT by a pumping system, an evaluation was conducted to assess the effects of the pumping system during periods of peak flows in the SLT and various plugging conditions of the debris plug. The 8,870-foot elevation has been established as a somewhat conservative maximum hydraulic head within the SLT especially for a "short-term" solution as it represents the point at which one or more of three relevant geotechnical factors of safety begin to be impinged upon (Atlantic Richfield, 2013). If there is at least some factor of safety left (especially for the case where the debris plug continues to function) unreasonable risk shouldn't be experienced. In the case of complete blockage of the debris plug, an unacceptable risk could be experienced; however, that case is unlikely to occur instantaneously, but rather build up over time and could be mitigated through appropriate response to a monitoring program.

With a pumping system installed in the SLT and set to begin pumping when the hydraulic head in the tunnel reaches elevation 8,865 ft, Table 3 shows the maximum hydraulic head elevation, the average hydraulic head elevation, percent of time that the pump will operate, and the percent of time that the hydraulic head elevation of 8,870 ft is exceeded. Each of these estimates is presented for various debris plug conditions from current flow through complete blockage. As shown, once the debris plug reaches approximately 50 percent reduction in flow, a critical elevation of 8,897 ft is reached and the model can no longer be used as a predictive tool. The stage capacity curve that was developed for the SLT and the NW and SE crosscuts only went up to 46 ft in head (46 ft above the invert of the tunnel – 8,851 ft). If the peak flows can't be accommodated with 46 ft of head (and approximately 600,000 cubic feet of storage) under certain model scenarios, the model can only predict that the maximum head would be something greater than what was modeled.

4.3 System Monitoring

The operation of the pumping system would be monitored for relevant conditions at an appropriate frequency to ensure that sudden or gradual decrease in the hydraulic conductivity of the debris plug, with the resultant increase in the head and storage volume of tunnel water, is observed in a timely manner to allow appropriate mitigation to be implemented. The monitoring would include, but is not necessarily limited to:

- Water head upgradient of the existing debris plug in BAH-01;
- Water flow at DR-3 (at its current or new location);
- Water quality, on an if/as-needed basis, above the existing debris plug in BAH-01;
- Water quality at DR-3 (at its current or new location), on an if/as needed basis; and
- Groundwater level and quality in selected monitoring wells, as necessary as part of the overall site monitoring plan.

It is assumed that water head in the tunnel and flow in the conveyance channel below the debris plug would be collected essentially continuously utilizing permanently installed and routinely maintained automated data collection equipment fit for the purpose. It is also assumed that this data would be: 1) accessible from appropriate off-site locations; 2) programmed to send an alarm condition when head or flow is outside established ranges; 3) monitored by trained, competent staff at an appropriate frequency (assumed at least weekly for an initial period of operation up to one year, and then monthly); and 4) reviewed by a qualified professional at least quarterly. Increase in head above a trigger level to be established would initiate action to mitigate the head build up.

4.4 Construction Plans

Design drawings for the proposed alternative are presented as Appendix A. Temporary measures will be implemented during construction to provide for the safety of workers and equipment from rocks rolling down the steep slopes in the terrain trap and potentially from the slope on the south side of the collapsed, open reach of the SLT. Such measures will likely include:

- Temporary barriers (e.g., concrete jersey barriers, braced steel panels, reinforced chain link fencing);
- Minimizing the time workers and equipment are in the terrain trap to the extent feasible; exclusion of workers from the south side of the open collapsed reach of the tunnel unless fully protected from slope instability or rolling rocks;
- Full-time observers watching for any evidence of slope instability (movement of cobbles or boulders, opening of cracks on or above the slope, erosional head-cutting, etc.) during work periods when workers or equipment are exposed to potential harm (especially following any precipitation events or an earthquake); and
- Shut-downs during and following rainfall, snowmelt events, and earthquakes until slope conditions can be assessed by competent persons and found safe to resume work.

5.0 System Operation and Maintenance

This section of the work plan provides a plan for operating and maintaining the hydraulic control measures system. Provided below is a description of the system components followed by general system operations procedures and control. A complete final operation and maintenance plan will be submitted once equipment has been purchased and installed.

5.1 System Components

The following system components comprise the hydraulic control measures system.

5.1.1 Pump

The main system component is a 6-inch by 6-inch self-priming centrifugal pump, Gorman Rupp Model T6A3S-B, or equivalent. The pump intake will be directly connected to the AT-2 casing with a flanged coupling. Intake and discharge manifolds will consist of gate valves, isolation flanges, and pressure gauges. A flow meter installed on the discharge manifold will display and record the instantaneous flow rate and total cumulative flow. The pump will be located in an enclosure to protect it from the elements.

5.1.2 Control Panel

A weather proof control panel will be located on the outside of the enclosure. The control panel will contain the pump motor starter, an operator interface, and a variable frequency drive (VFD). The VFD will receive signals from the pressure transducer described below. These signals will control pump start, stop, and control operational speed based on the water level in the adit. The pump may also be controlled manually via the operator interface. The control panel will include external lighting to indicate operation or an alarm condition.

5.1.3 Pressure Transducer

A pressure transducer will be installed in the open rock portion of the SLT as accessed through casing and a rock-cored interval of BAH-01. The pressure transducer will be correlated with the critical water level elevations in the adit to turn the pump on and off. Since BAH-01 is located approximately 200 ft from the control panel location, telemetry or a cable may be used to broadcast the signal to the control panel.

5.1.4 Piping

Steel piping will be installed from the AT-2 casing to the pump manifold. The 4-inch diameter steel pipe will be enlarged to 6-inch diameter steel piping to match the pump intake and discharge. The discharge piping will be transitioned to high density poly ethylene (HDPE) at the pump discharge manifold. The 6-inch HDPE will convey water to the existing conveyance channel located near the old Lime Plant building. The piping will include flanges for maintenance and pipe cleaning access.

5.2 System Operational Controls

The system operational controls consist of start-up and shut-down of the pump, based on water level in the adit.

5.2.1 Start-up

- Ensure valves GV-001 and GV-002 are open.
- Verify ALL alarm conditions have been cleared on the controller.
- Verify that the water level in BAH-01 is at water elevation of 8,855 ft above mean seal level (amsl) or greater (level of AT-2 intake).

- Ensure that HS-01 is in the "Hand" position.
- Press the START button on the controller.
- Adjust GV-002 to approximately 30 percent closed applying back pressure to provide maximum flow through the discharge piping.
- Slowly open GV-002 while observing the flow rate at FI-01 and adjust to the maximum flow possible at the water level conditions (600-1,000 gpm).

5.2.2 Normal Operations

Initial start-up of the pump will automatically occur when the water in the adit reaches the critical elevation of 8,865 ft amsl. During the initial start-up, valve GV-002 shall be adjusted to apply proper back pressure on the pump to ensure maximum flow from the pump without cavitation. Prior to initial start-up, proper pump rotation will be tested by an electrician during installation. Following initial start-up, the pump will be started automatically, based on signals received from the pressure transducer. To manually start-up the pump, a water elevation of 8,855 ft amsl or greater shall be confirmed before starting the pump which is the level of the intake of the AT-2.

5.2.3 Shut-Down

Auto shut-down will occur once the water level in the adit reaches an elevation of 8,855 ft amsl. If the pump needs to be shut-down for maintenance or emergency conditions, HS-01 should be turned to the "Off" position and valves GV-001 and GV-002 should be closed.

6.0 System Maintenance

A final operations and maintenance plan will be prepared once the equipment is purchased and installed. The final plan will include the information listed below:

Equipment List. This list will provide a complete list of all equipment and instrumentation, including the Equipment Name and Equipment Identification. This information can be cross-referenced to the Piping and Instrumentation Diagram provided in the drawings along with the manufacturer and model number for each.

Maintenance Schedule. These tables provide manufacturer recommended maintenance for equipment and the scheduled frequency of the recommended maintenance.

Equipment Manuals and Cut Sheets. This information will include manuals for the main equipment items and cut sheets for instrumentation and appliances.

Contractor Submittals. This information will include contractor submittals of equipment and materials used to install the system.

7.0 References

AECOM, 2013. *Preliminary Design Report, St. Louis Tunnel Hydraulic Control Measures, Rico-Argentine Mine Site – Rico Tunnels, Operable Unite OU01, Rico, Colorado.* Denver, CO: AECOM. October 30, 2013

Atlantic Richfield, 2013. *Adit and Portal Investigation Report – 2013 Update, St. Louis Tunnel Hydraulic Control Measures, Rico Argentine Mine Site, Rico Tunnels Operable Unit OU01, Rico, Colorado.* October 30.

U.S. Bureau of Reclamation, 2011. *Design Standards No. 13, Embankment Dams.* October.

USEPA, 2011a. *Unilateral Administrative Order for Removal Action, U.S. EPA Region 8, Docket No. CERCLA-08-2011-0005; Rico-Argentine Site, Dolores County, Colorado.* March 23.

USEPA, 2011b. *Removal Action Work Plan. Rico-Argentine Mine Site – Rico Tunnels Operable Unit OU01, Rico, Colorado.* March 9.

Tables

Table 1 Design Parameters Used in Hydraulic Model

Condition	Number of Relief Wells	Relief Well Length (feet)	Relief Well Diameter (inches)	Tunnel Invert Elevation (feet)	Relief Well Outlet Elevation (TOC) (feet)	Relief Well Angle (degrees)	Debris Plug Flow?	Bulk k-value (cm/s)
Pre - AT-2	0	NA	NA	8,851	NA	NA	Yes	3.9
AT-2 as Gravity Relief Well	1 (AT-2)	21	4.25	8,851	8,866	32	Yes	3.9
Pumping System at AT-2	Pump from AT-2 at 1000 gpm	NA	NA	8,851	NA	NA	Yes	3.9

Notes:
TOC = top of casing cm/s = centimeters per second gpm = gallons per minute

Table 2 Output Statistics

Condition	Max Head (feet)	Post 1999 Max Head (feet)	Average Head (feet)	Max Outflow (cf/s)	Average Outflow (cf/s)	Max Storage (cf/s)	Average Storage (cf/s)
Pre - AT-2	44	41	13	5.1	1.5	566,000	107,000
AT-2 as Gravity Relief Well	29	27	12	5.2	1.5	272,000	90,000
Pumping System at AT-2	25	22	11	5.1	1.5	234,000	82,000

Note:
cf/s = cubic feet per second

Table 3 Effects of Pumping System During Periods of Peak Flows

Debris Plug Condition	Maximum Elevation (amsl)	Average Elevation (amsl)	Percent of Time Pump Operates	Percent of Time 8,870 feet Exceeded
Current Flow	8,876	8,862	33%	3.9%
25% Reduction in Flow	8,885	8,864	56%	4.6%
50% Reduction in Flow	>8,896	--	--	--

Notes:
amsl = above mean sea level % = percent

Figures

Filename: Z:_CURRENT_PROJECTS\ATLANTIC RICHFIELD\60157757 RICO\000_CADD\06-EXHIBITS\47_FINAL DESIGN REPORT - AHC\2014-ADIT-FDR_FIG-1.1_SITE-MAP_RICO.DWG Last saved by: RODDENA Last Plotted: 4/24/2014 11:00 AM Project Management Initials: Designer: Checked: Approved: ANSI A 8.5" x 11"

RICO-ARGENTINE SITE-OU01

FINAL DESIGN REPORT ST. LOUIS TUNNEL HYDRAULIC CONTROL MEASURES

FIGURE 1 - SITE MAP

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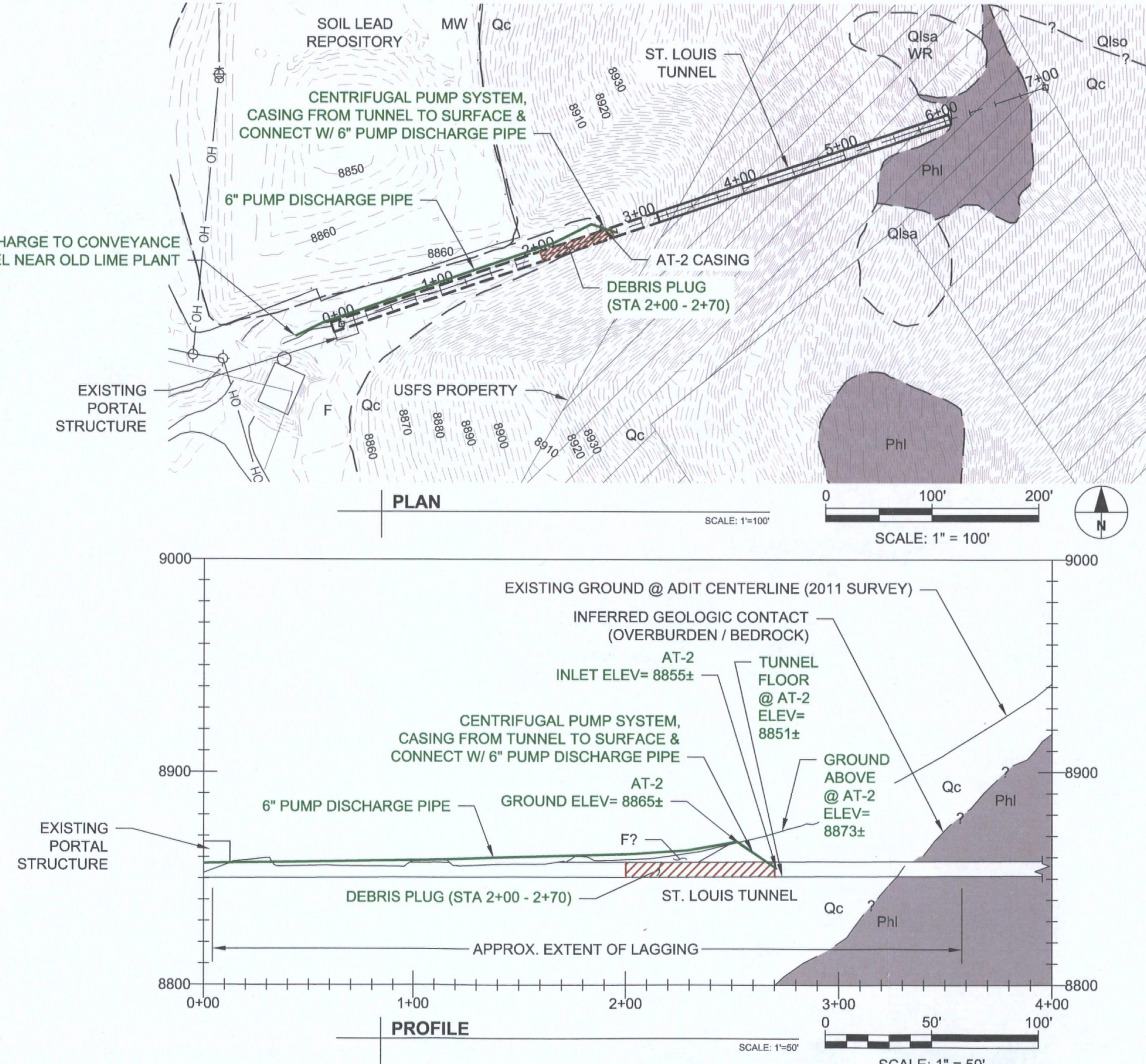
LEGEND:

F	FILL
MW	MINE WASTE
WR	WASTE ROCK
Phl	HERMOSA FORMATION
Qc	COLLUVIUM
Qlsa	ACTIVE LANDSLIDE DEPOSIT



RICO-ARGENTINE SITE-OU01

FINAL DESIGN REPORT ST. LOUIS TUNNEL HYDRAULIC CONTROL MEASURES

FIGURE 2 - PUMPING SYSTEM PLAN & PROFILE

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APRIL 2014

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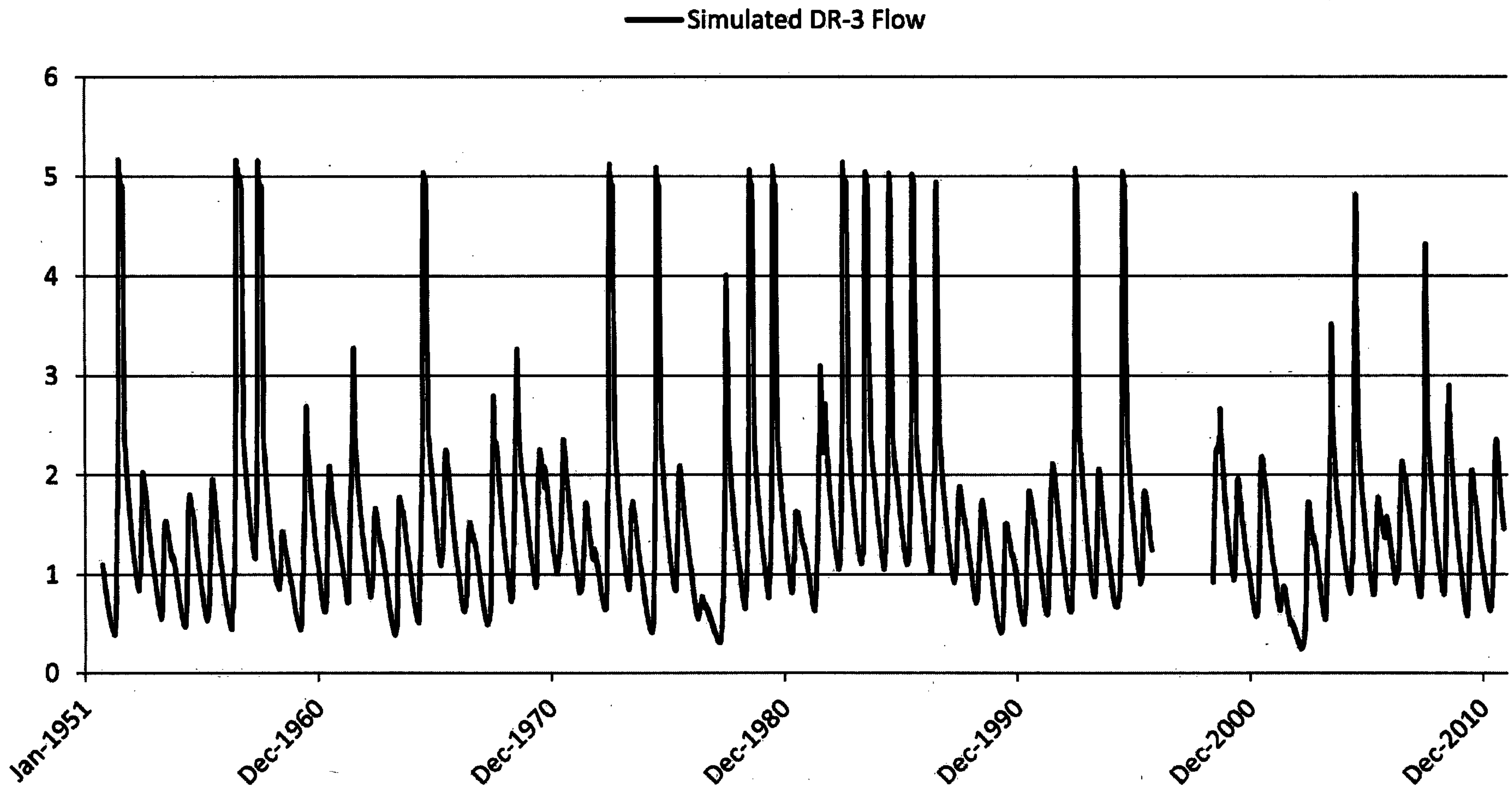
Filename: Z:_CURRENT_PROJECTS\ATLANTIC RICHFIELD\60157757 RICO\000_CADD\06-EXHIBITS\47_FINAL DESIGN REPORT - AHC\2014-ADIT-FDR_FIG-1_3_4_RICO.DWG Last saved by: RODDENA Last Plotted: 4/24/2014 11:43 AM Project Management Initials: Designer: ____ Checked: ____ Approved: ____ ANSI A 8.5" x 11"



RICO-ARGENTINE SITE-OU01

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FINAL DESIGN REPORT ST. LOUIS TUNNEL HYDRAULIC CONTROL MEASURES

FIGURE 3 - PREDICTED DR-3 FLOW RATE BASED ON THE RICO UNDERGROUND WORKINGS HYDRAULIC MODEL 60314368

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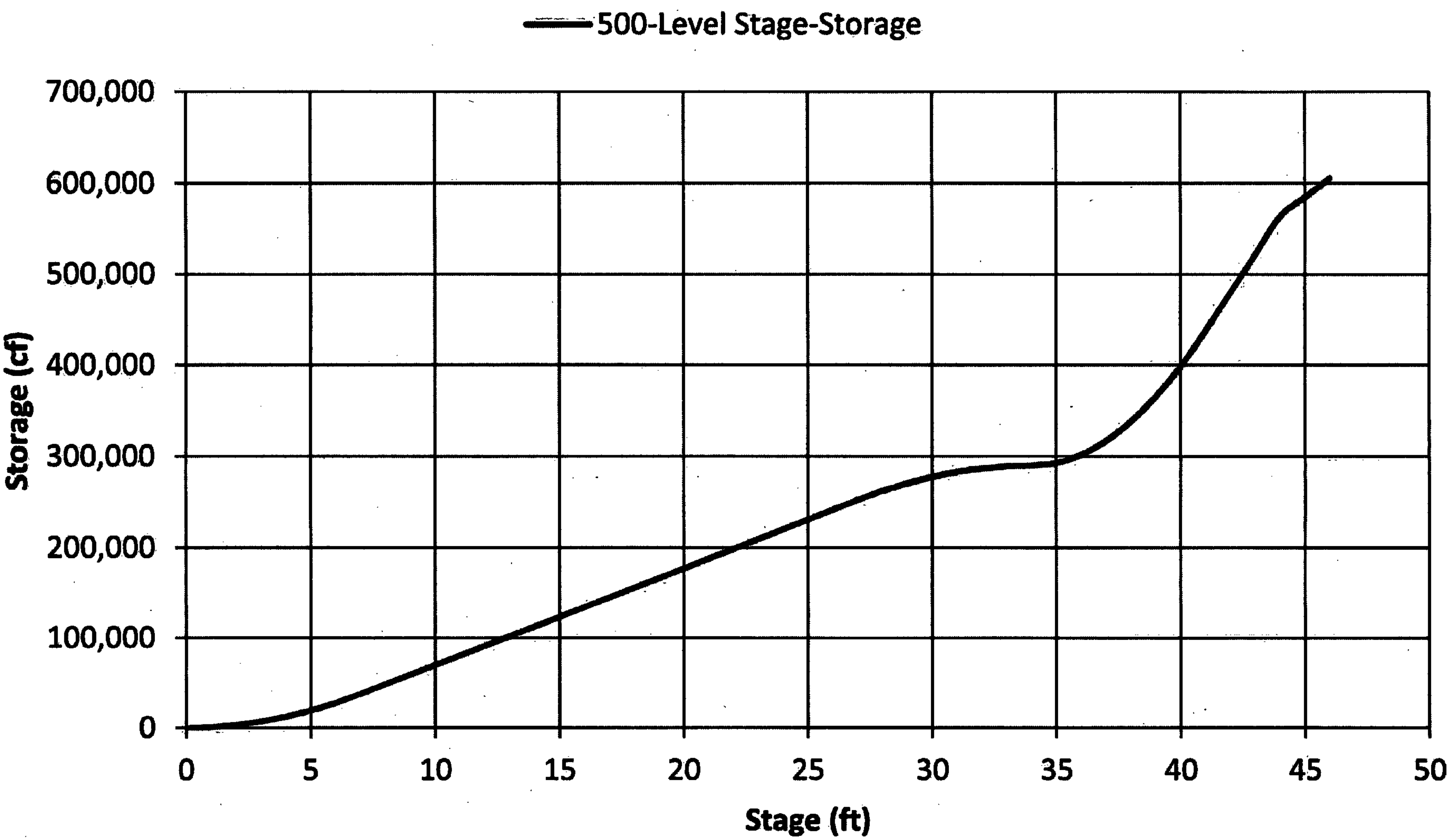

RICO-ARGENTINE SITE-OU01

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FINAL DESIGN REPORT ST. LOUIS TUNNEL HYDRAULIC CONTROL MEASURES

FIGURE 4 - STAGE-STORAGE RELATIONSHIP FOR 500 LEVEL UNDERGROUND WORKINGS

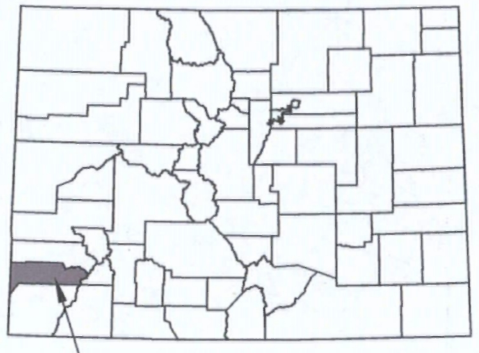
60314368

Appendix A

Construction Drawings

RICO-ARGENTINE SITE-OU01

ST. LOUIS TUNNEL HYDRAULIC CONTROL SYSTEM



DOLORES COUNTY

STATE OF COLORADO
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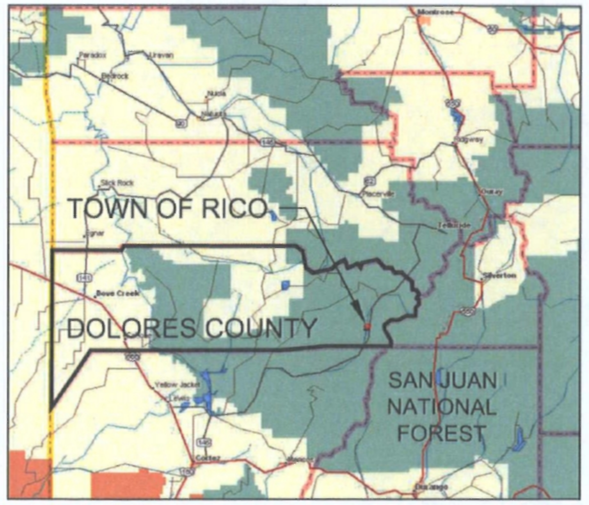

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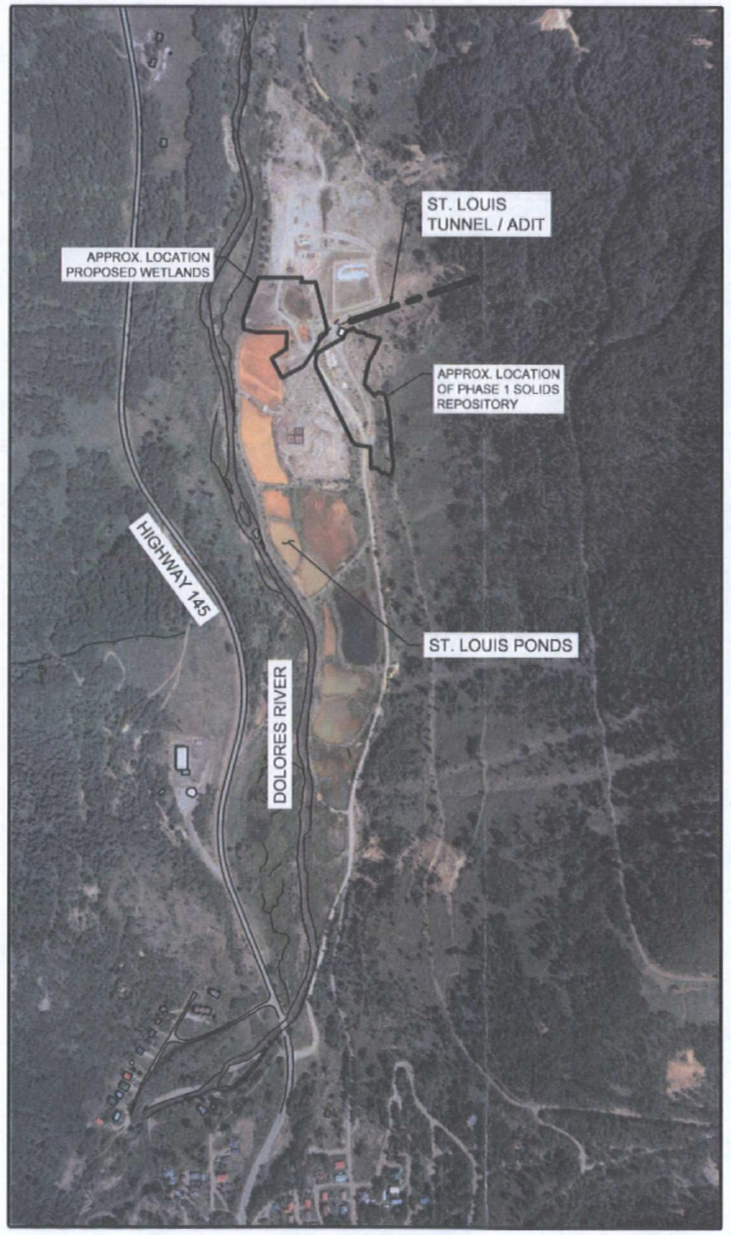

VICINITY MAP
SCALE: 1" = 500'

0 500' 1000'
1" = 500'

N

SHEET INDEX

1. COVER SHEET
2. C-101 SLT HYDRAULIC CONTROL SYSTEM SITE LAYOUT
3. D-601 PROCESS FLOW DIAGRAM AND SYSTEM PIPING AND INSTRUMENTATION DIAGRAM
4. M-101 MECHANICAL DETAILS
5. E-101 ADIT PUMP 1-LINE DIAGRAM

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RICO-ARGENTINE SITE-OU01
ST. LOUIS TUNNEL
HYDRAULIC CONTROL SYSTEM

APRIL 2014

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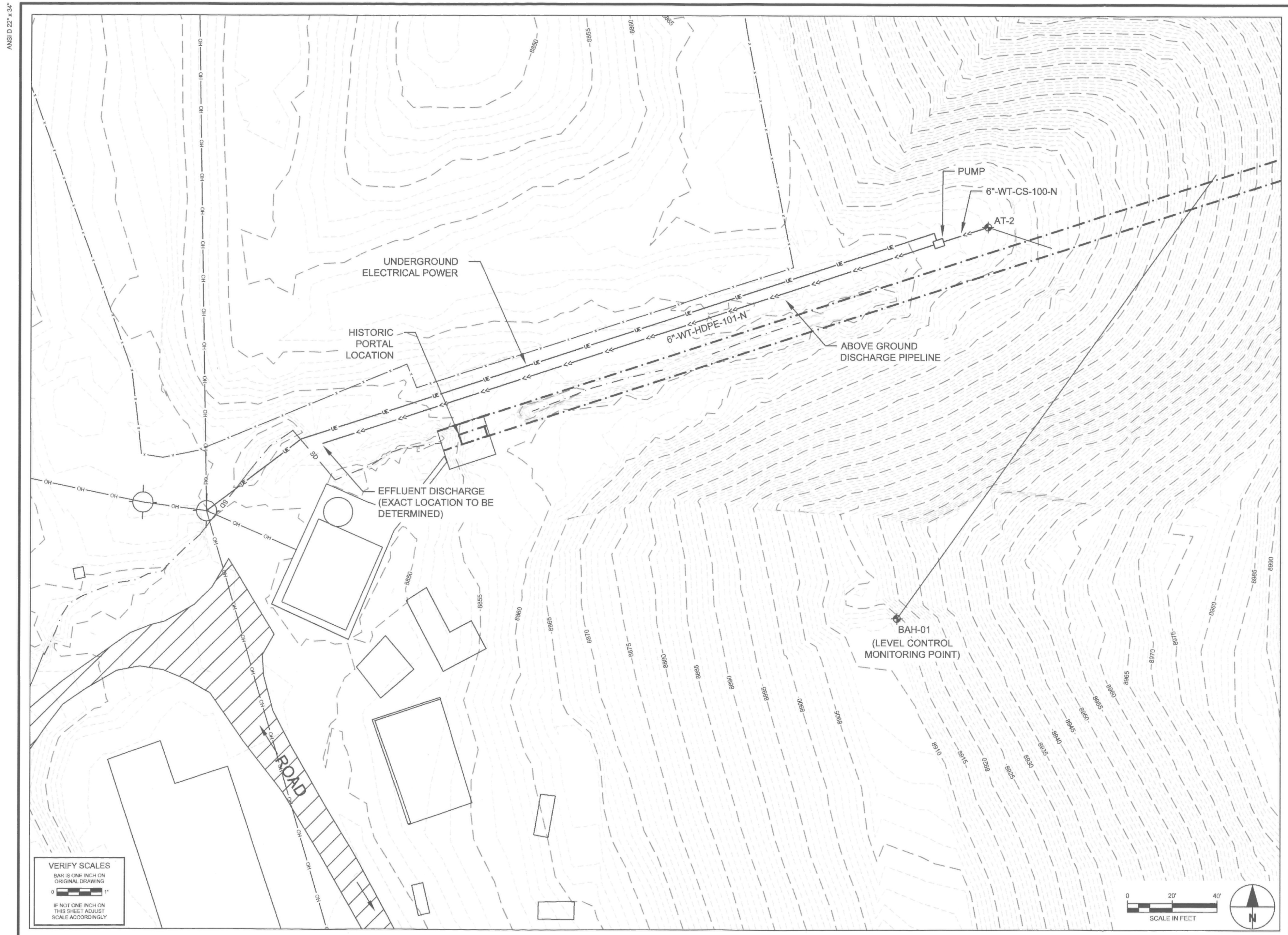

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PROJECT

RICO-ARGENTINE SITE-OU01

ST. LOUIS TUNNEL HYDRAULIC CONTROL SYSTEM

CLIENT

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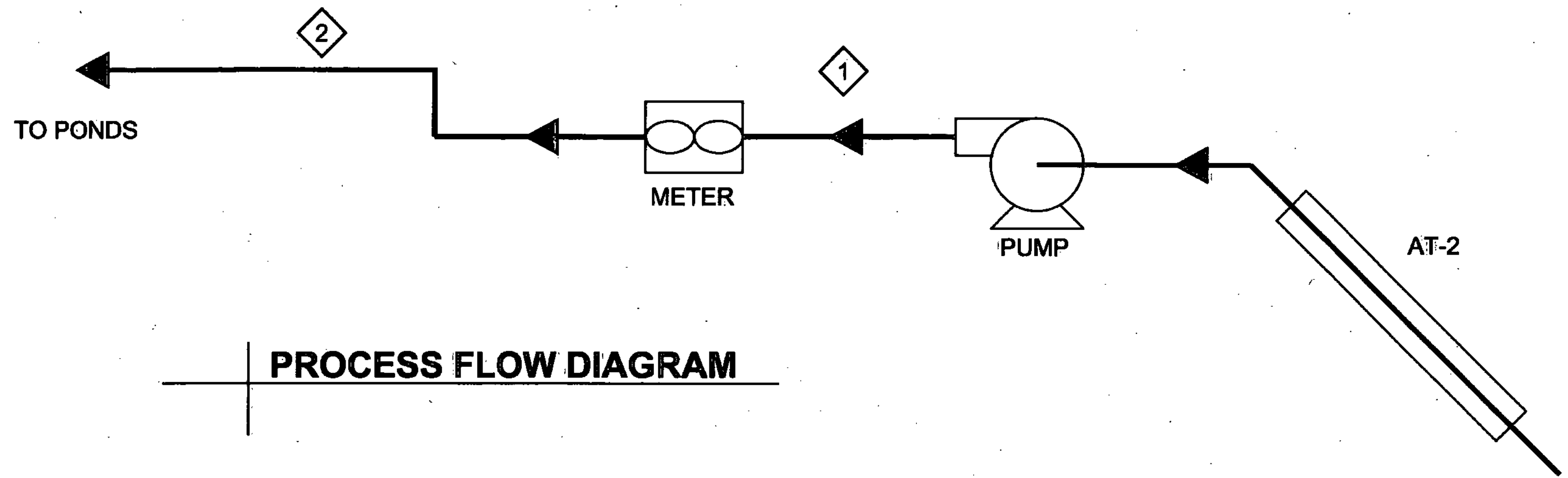
SHEET TITLE

SLT HYDRAULIC CONTROL SYSTEM SITE LAYOUT

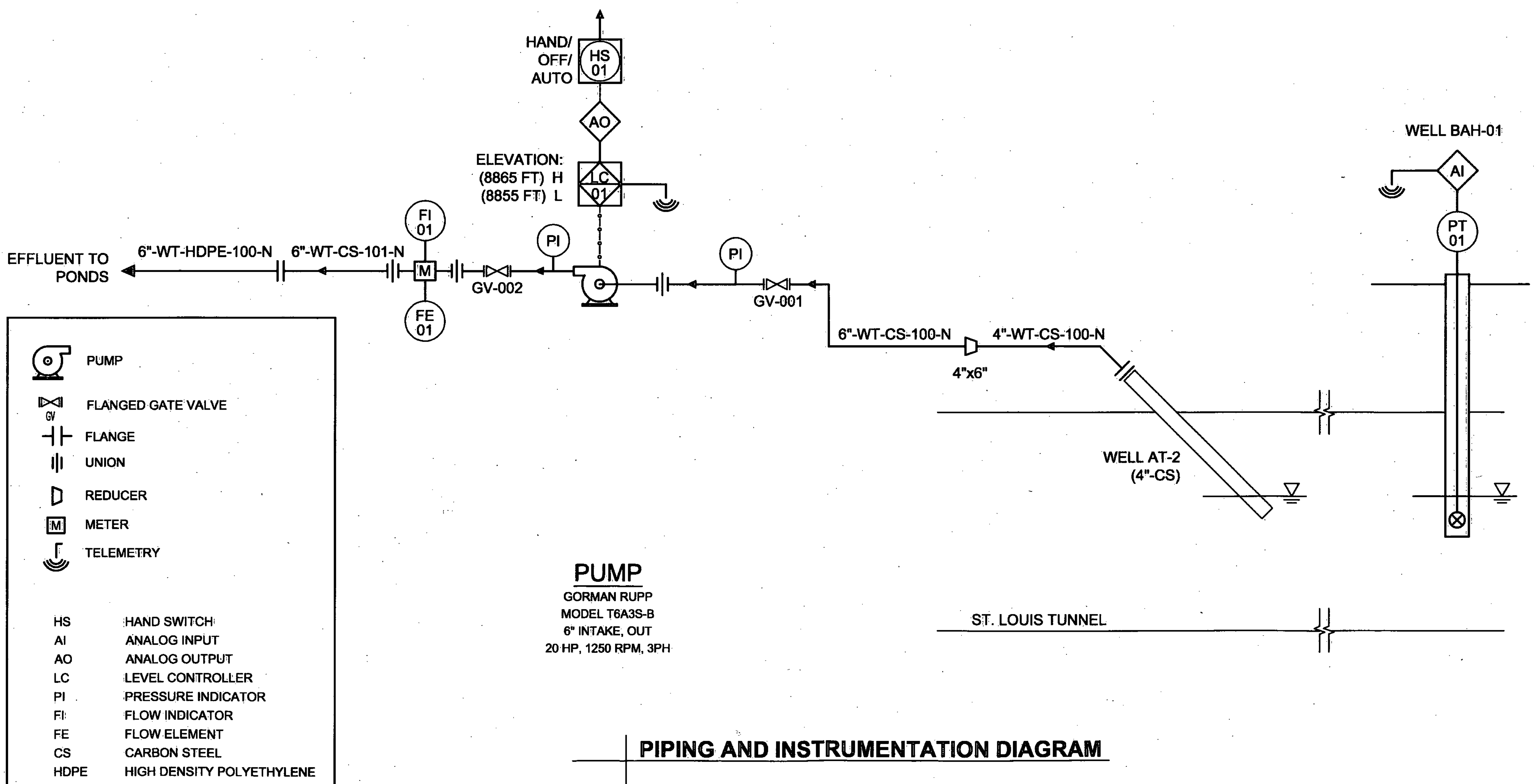
SHEET NUMBER

C-101

PIPE RUN	1	2
PHASE	WATER	WATER
FLOW (GPM)	1000	1000
PRESSURE (psi)	22	13



PROCESS FLOW DIAGRAM



PIPING AND INSTRUMENTATION DIAGRAM

ANSI D 22" x 34"

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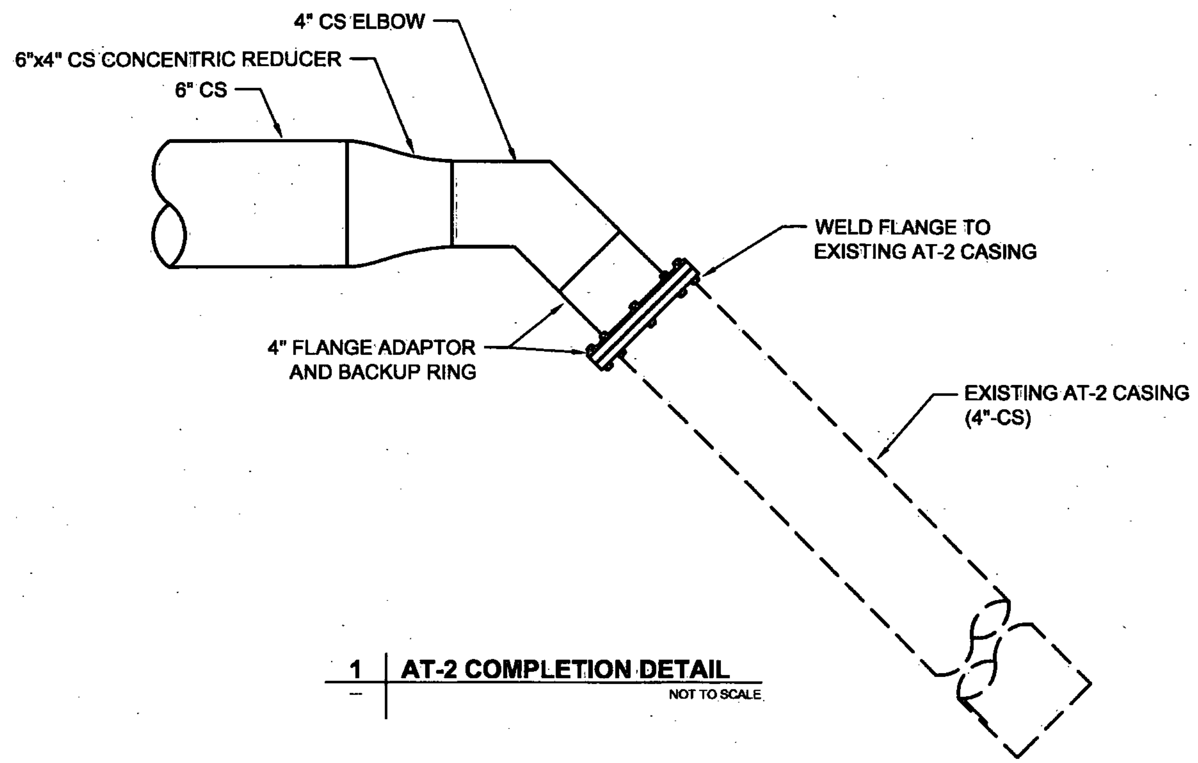
PROCESS FLOW DIAGRAM AND SYSTEM PIPING AND INSTRUMENTATION DIAGRAM

SHEET NUMBER

D-601



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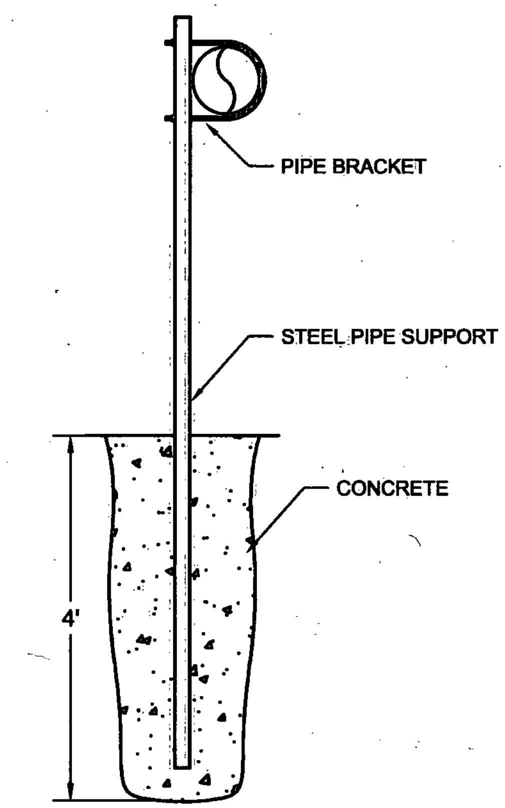

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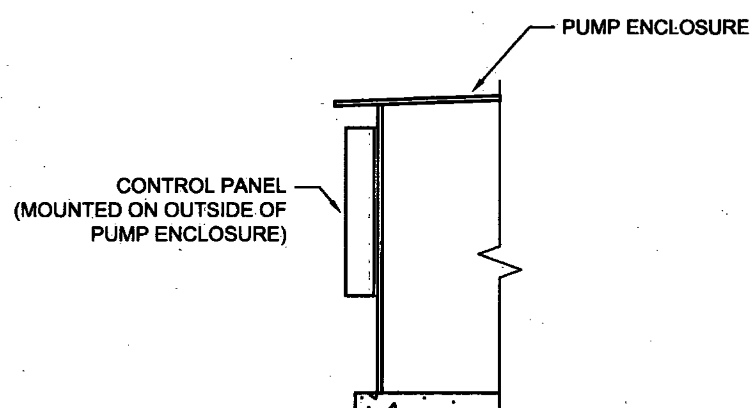

4 | CONTROL PANEL LOCATION
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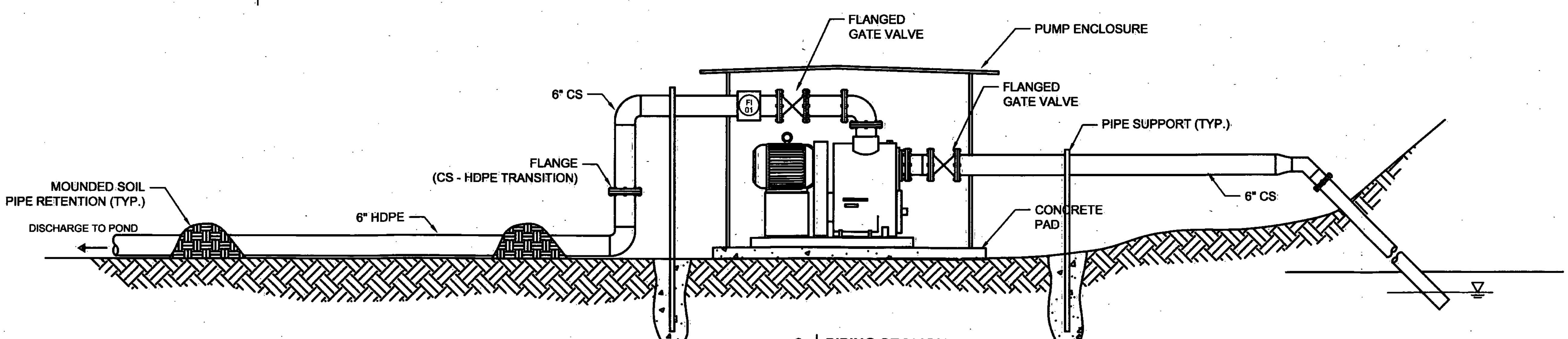

2 | PIPING SECTION
— NOT TO SCALE

ANSI D 22" x 34"

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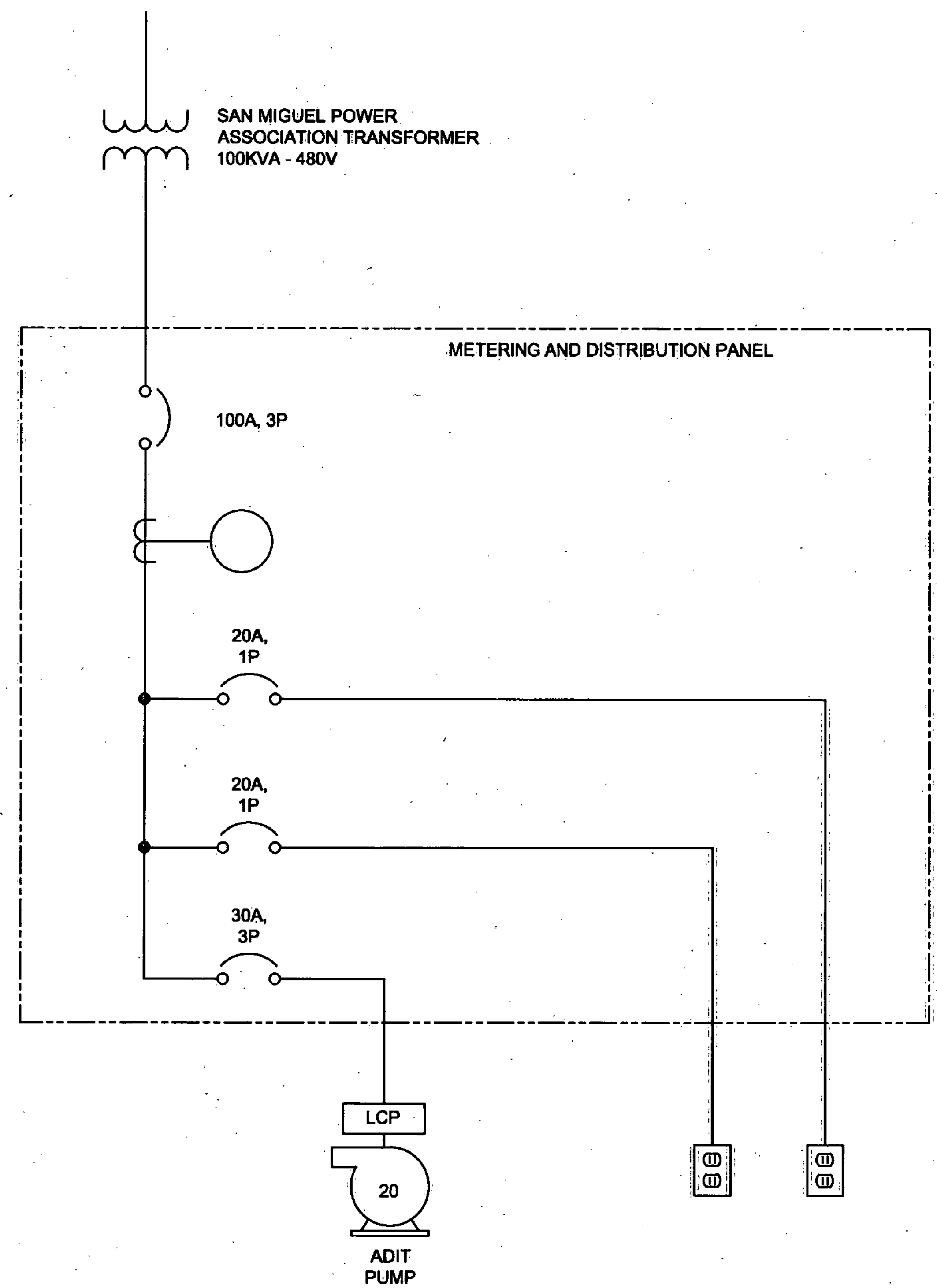
MECHANICAL DETAILS

SHEET NUMBER
M-101

ANSI D 22" x 34"



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SHEET TITLE

ADIT PUMP
1-LINE DIAGRAM

SHEET NUMBER

E-101